

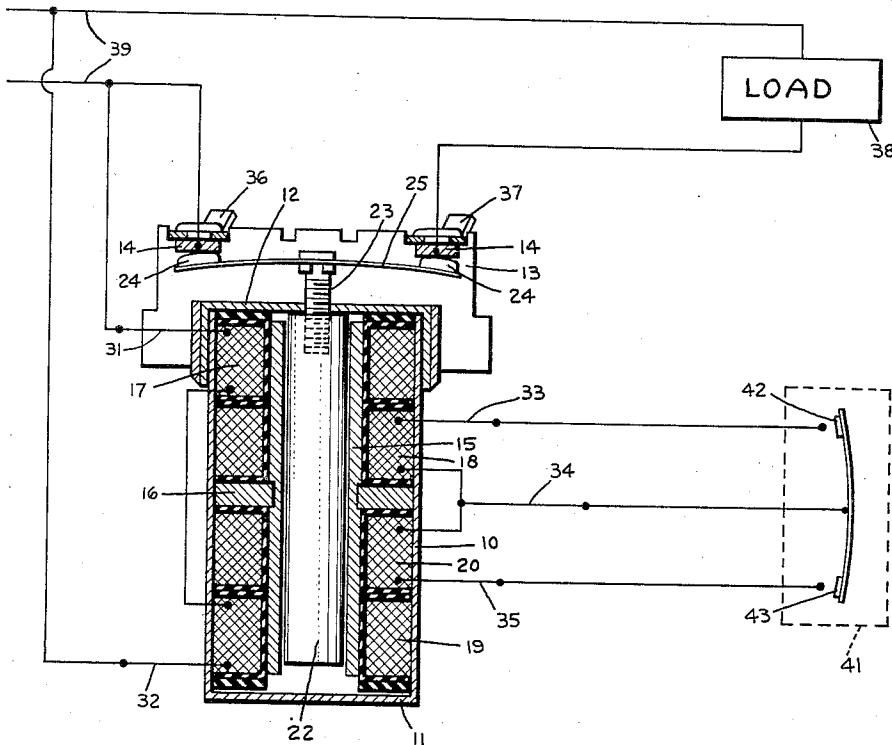
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SOLENOID-OPERATED RELAY

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Fig. 1.



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SOLENOID-OPERATED RELAY

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This invention relates to a solenoid-operated relay; more particularly, it is related to a solenoid-operated relay adapted for permanent connection across a high-voltage line and arranged for energization upon the completion of an isolated low-voltage inductive circuit.

In recent years, so-called remote control wiring systems have become popular in the field of residential lighting due to the fact that they enable lights to be controlled from as many locations as may be desired, the control being exercised through a simply wired, inexpensive low-voltage circuit. In remote control wiring systems, a relay energizable by voltages of the order of 24 volts, for example, is utilized to control each lighting circuit. Energizing voltage for the relay is provided by a transformer which reduces the incoming voltage, usually 120 volts, to the desired level, usually 24 volts. A single transformer is sufficient for the operation of a number of relays. Relays suitable for conventional remote control systems are described and claimed in Hutt Patent No. 2,324,844 and Reihman Patent No. 2,738,395, both of which are assigned to the same assignee as the present invention. The transformer may be any conventional low-power transformer designed for permanent connection across a high-voltage line, with an isolated secondary winding.

While the conventional remote control system described above is highly satisfactory in its operation, it is somewhat lacking in flexibility. For example, it would not be economically feasible to convert just a single room of a house to remote control operation while retaining conventional high-voltage switches in the remainder of the house. As a result, remote control systems have been reserved almost exclusively for new residential construction. Nevertheless, many occasions arise when it would be desirable in replacing a single lighting circuit to convert to remote control operation. Accordingly, the present invention has as one of its objects to provide a remote control relay which does not require a separate transformer for stepping down high-voltage to low-voltage but which nevertheless has the high-voltage circuit electrically isolated from the low-voltage control circuit.

Another object of the present invention is to provide a solenoid-operated relay wherein operation is controlled by the selective completion of one of two inductive circuits.

Another object of the invention is to provide a solenoid-operated relay having two coils arranged for permanent connection across a high-voltage line with a minimum power consumption.

The accomplishment of these and other objects will be apparent from the following specification considered in conjunction with the annexed drawing which is a sectional view of the relay of the present invention together with a diagram of the circuit in which the relay is incorporated.

Briefly stated, in accordance with one of its aspects, the present invention is directed to a solenoid-operated

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relay comprising a pair of spaced, high-voltage, primary electromagnetic coils surrounding and defining an axial passageway, the coils being adapted for permanent connection to a source of high-voltage, a low-voltage coaxial secondary electromagnetic coil inductively coupled to each high-voltage primary coil, each secondary coil being adapted for closing its circuit to selectively neutralize the magnetic effect of the primary coil inductively coupled thereto, a ferromagnetic solenoid-plunger reciprocally movable along the axis of the passageway by the selective closing of the circuits of the secondary coils, and electrical contacts movable with the plunger to open and close as the plunger moves back and forth.

Referring to the drawing, the relay consists of a cylindrical ferromagnetic housing 10 having a solid ferromagnetic end piece 11 at one end and a ferromagnetic end piece 12 at the other end with a central aperture therein. Mounted upon the housing 10, as by riveting, is a cap 13 of insulating material in which is mounted a pair of stationary contacts 14.

Extending along the axis of the housing 10 is a tube 15 of ferromagnetic material. Preferably, there is a gap between the tube 15 and the end pieces 11 and 12. An annular ring 16 of ferromagnetic material divides the space on that portion of the interior of cylinder 10 which is outside the tube 15 into two approximately equal spaces. In one space there is a high-voltage primary electromagnetic coil 17 and low-voltage secondary coil 18 inductively coupled thereto, both coils being positioned around the tube 15. Similarly, the other space has a high-voltage primary electromagnetic coil 19 and low-voltage secondary electromagnetic coil 20 inductively coupled thereto, both coils being mounted upon the tube 15. Typically, the high-voltage primary coils 17 and 19 may consist of 3,000 turns of #40 wire and the low-voltage secondary coils 18 and 20 may consist of 700 turns of #34 wire. The wire size and the number of turns may be varied as the voltage requirements vary.

Positioned for back-and-forth movement within the tube 15 is a solenoid-plunger 22 of ferromagnetic material. A contact mounting pin 23, preferably composed of nylon or similar plastic material, positioned upon the solenoid-plunger 22 extends through the aperture in the end piece 12 and serves as a means for mounting a flexible arm 25 upon which a pair of movable contacts 24 are positioned. The flexible arm 25 is composed of a good electrical conductor since it becomes part of a high-voltage circuit when the contacts 24 engage the contacts 14.

The high-voltage primary electromagnetic coils 17 and 19 are preferably connected in series. The low-voltage secondary coils 18 and 20 are connected for independent completion of their circuits although such completion can take place through a common lead as illustrated. Thus, in a preferred embodiment, there are two high-voltage primary leads 31 and 32 for permanent connection across a high-voltage line 39 such as is provided by 120-volt residential service; and three low-voltage secondary leads 33, 34, and 35, 34 being the common connection, and two terminals 36 and 37 through which power is supplied to control a load 38. The circuit is under the manual control of a push-button switch 41 having contacts 42 and 43 which are preferably arranged for momentary closing. The switch 41 may be positioned a considerable distance from the relay and there may be a number of such switches at different points exercising the control function through a circuit connecting them to the leads 33, 34, and 35.

The electromagnetic coils 17, 18, 19, and 20 have been described as "primary" or "secondary" because they perform, in effect, the function of a pair of transformer units. The two units will draw current and power in their

primary windings in keeping with the requirements of their respective magnetic circuits.

It was previously mentioned that there is preferably a gap between the ferromagnetic tube 15 and the end pieces 11 and 12. The end gaps are important because they result in an imbalance between the magnetic circuits provided on the one hand by the coils 17 and 18 and on the other hand by the coils 19 and 20. With the solenoid-plunger 22 flush with the end piece 12 as illustrated in the drawing there is no magnetic gap between the end piece 12 and the solenoid-plunger. The solid path of ferromagnetic material provides a magnetic circuit of low reluctance from the end piece 12 through the solenoid plunger 22, the annular ring 16 and the housing 10 back to the end piece 12. The complementary magnetic circuit through the end piece 11 is of high reluctance due to the gap between the end piece 11 and solenoid-plunger 22. As a result, the line voltage is not divided evenly between the high-voltage coils 17 and 19. Instead, the coil 17 takes about 86 volts and the coil 19 about 34 (assuming a line voltage of 120 volts). The voltage induced in the secondary coil 18 is about 13 volts while that in the secondary coil 20 is about 2.5 volts.

Let it be assumed that the switch contacts 42 are closed to complete the circuit of the secondary winding 18. The shunting of the coil 18 creates a demagnetizing effect on one end of the plunger 22 and also reduces the reluctance of the primary coil 17 which has been limiting the line current. The increase in the line current increases the magnetic attraction on the plunger 22 from the direction of the end piece 11 at the same time that the magnetic attraction from the direction of the end piece 12 is destroyed by the demagnetization effect caused by shunting the coil 18. Thus the force tending to hold the solenoid-plunger 22 against the end piece 12 not only is neutralized the solenoid-plunger 22 is strongly impelled in the direction of the end piece 11 and ends up flush against the said end piece. This shifts the magnetic circuit of low reluctance from the path passing through the end piece 12 to the path passing through the end piece 11. The solenoid-plunger 22 is then held firmly in engagement with the end piece 11 in the same manner that it was previously held in engagement with the end piece 12.

Though the solenoid-plunger requires but minute electrical power to be moved from the closed contact to the open contact position (or conversely) because of the combined aiding reactions in the two magnetic circuits of the transformer units, the solenoid-plunger seats into its changed position with a very strong locking action. This is caused by the strong magnetic forces created by the primary windings 17 and 19 tending to retain the solenoid-plunger 22 (or the reluctance of its magnetic circuit) in that condition after the control circuits through the secondary windings 18 and 20 are open. This seating effect together with the sensitive trigger action enables the relay contacts to maintain a setting without an over-center spring mechanism of the type illustrated in Reihman application S. N. 322,055 filed November 22, 1952.

Since the two primary windings 17 and 19 are series-connected, a continued closed circuit of one of the control secondary windings 18 and 20 has little effect on the power consumed since the movement of the solenoid-plunger to its opposite setting reduces the voltage across the shunted secondary winding to about 2.5 volts. At this voltage, the demagnetizing current is too low to be destructive. Consequently there is no overheating sufficiently serious to destroy the windings even though one of the secondary windings 18 and 20 is continuously short-circuited.

While the relay has been described with reference to a specific embodiment, it is obvious that many changes may be made therein without departing from the spirit of this invention. Therefore, it is the intention that the invention be limited only as may be necessitated by the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A solenoid-operated relay comprising a pair of spaced high-voltage primary electromagnetic coils surrounding and defining an axial passageway, said coils being adapted for permanent connection to a source of high-voltage, a low-voltage coaxial secondary electromagnetic coil inductively coupled to each high-voltage primary coil, each secondary coil being adapted for closing its circuit to selectively neutralize the magnetic effect of the primary coil inductively coupled thereto, a ferromagnetic solenoid-plunger reciprocally movable along the axis of said passageway by the selective closing of the circuits of said secondary coils, and electrical contacts movable with said plunger to open and close as said plunger moves back-and-forth.

2. A solenoid-operated relay comprising a cylindrical ferromagnetic housing, a partition defining an axial passageway inside said housing, a pair of spaced high-voltage primary electromagnetic coils surrounding said partition, said coils being adapted for permanent connection to a source of high-voltage, a low-voltage secondary electromagnetic coil for each of said primary coils inductively coupled thereto and also surrounding said partition, each secondary coil being susceptible to shorting in order to exert a demagnetizing effect upon the primary coil inductively coupled thereto, a ferromagnetic solenoid-plunger selectively movable through said passageway by the shorting of said secondary coils, and electrical contacts movable with said plunger to open and close as said plunger moves back-and-forth.

3. A solenoid-operated relay as claimed in claim 2 wherein the two primary electromagnetic coils are connected in series.

4. A solenoid-operated relay comprising a cylindrical ferromagnetic housing, a partition defining an axial passageway inside said housing, a first high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively coupled thereto positioned around said passageway at one end thereof, a second high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively coupled thereto positioned around said passageway at the other end thereof, a ferromagnetic plunger movable back-and-forth through said passageway as said secondary coils are alternately subjected to a short circuit, and electrical contacts movable with said plunger to open and close as said plunger moves back-and-forth.

5. A solenoid-operated relay comprising a cylindrical ferromagnetic housing, a partition defining an axial passageway inside said housing, a first high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively coupled thereto positioned around said passageway at one end thereof, a second high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively coupled thereto positioned around said passageway at the other end thereof, an annular ferromagnetic separator between said first and second primary coil-secondary coil combinations, a ferromagnetic plunger movable back-and-forth through said passageway as said secondary coils are alternately subjected to a short circuit, and electrical contacts movable with said plunger to open and close as said plunger moves back-and-forth.

6. A solenoid-operated relay comprising a cylindrical ferromagnetic housing, a partition defining an axial passageway inside said housing, high-voltage secondary electromagnetic coils positioned around said partition at opposite ends of said passageway, a pair of low-voltage secondary electromagnetic coils abutting said primary coils in axial alignment around said partition at the central portion of said passageway, each of said secondary coils being inductively coupled to the abutting primary coil, a ferromagnetic separator between said secondary coils, a ferromagnetic solenoid-plunger selectively mov-

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able through said passageway by the shorting of said secondary coils, and electrical contacts movable with said plunger to open and close as said plunger moves back-and-forth.

7. A solenoid-operated relay comprising a cylindrical ferromagnetic housing closed at one end, the other of said ends also being closed except for a central aperture therein, a tube inside said housing defining an axial passageway in alignment with said central aperture, an annular ferromagnetic separator on the interior of said space dividing said interior into two substantially equal annular spaces, a high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively coupled thereto wound around said tube in each of said spaces, a solenoid-plunger in said tube movable between the ends of said housing, a contact mounting pin mounted upon said solenoid-plunger and extending through said central aperture, and electrical contacting means mounted upon said mounting pin and movable with said solenoid-plunger to open and close an electrical switch as said primary coils are selectively demagnetized by closing the circuits of the secondary coils inductively coupled thereto.

8. A solenoid-operated relay comprising a cylindrical ferromagnetic housing closed at one end, the other of said ends being closed except for a central aperture therein, a tube inside said housing defining an axial passageway in alignment with said central aperture, an annular ferromagnetic separator on the interior of said space dividing said interior into two substantially equal annular spaces, a high-voltage primary electromagnetic coil and low-voltage secondary electromagnetic coil inductively cou-

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pled thereto wound around said tube in each of said spaces, a solenoid-plunger in said tube movable between the ends of said housing, a contact mounting pin mounted upon said solenoid-plunger and extending through said central aperture, stationary electrical contacting means fixedly positioned with respect to said housing, and electrical contacting means mounted upon said mounting pin and movable with said solenoid-plunger to make and break contact with said stationary contacting means as the magnetic effect of said primary coils on said solenoid plunger is selectively neutralized by completing the circuits of the secondary coils inductively coupled thereto.

9. A solenoid-operated relay as claimed in claim 8 wherein the high-voltage primary coils are connected in series.

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